Systems Analysis
Summary of Annual Merit Review Systems Analysis Subprogram

Summary of Reviewer Comments on Systems Analysis Subprogram:

The reviewers considered the Systems Analysis Subprogram to be an essential component to the Hydrogen Program mission and critical to the President's Hydrogen Fuel Initiative. The projects are considered to be appropriately diverse and strongly focused on addressing technical barriers and meeting targets.
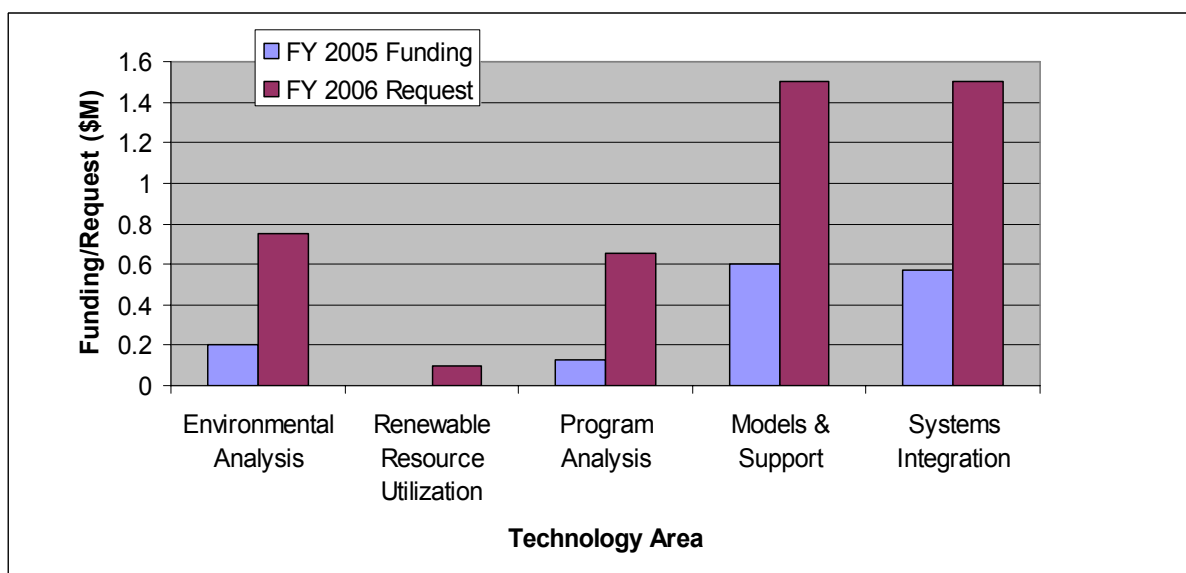
In general, the reviewers noted that Systems Analysis is a complex subprogram but is receiving the appropriate management attention. Some reviewers commented that the Program is covered finally by a "long needed" plan, which is consistent with addressing the comprehensive list of identified barriers.

The major concerns identified by the reviewers for Systems Analysis were: 1) coordination and cooperation with other parts of the Program (and other DOE offices, e.g., Fossil Energy and Nuclear Energy) is required; 2) the plan for how the analytical parts fit together should be defined; and 3) roles of the various models should be described. The Systems Analysis subprogram is in the first year of existence and these issues will be addressed in the Systems Analysis Plan which is in the development phase.

Finally, the reviewers commented on the significant funding planned for FY2006 and the need, if required, for cost reduction without sacrificing results. It should be noted that the 2004 National Academies' Report identified the requirement for the Systems Analysis function to address the complexity of the Hydrogen Program and recommended the funding for this subprogram should be ~$10 million/year. The subprogram is in the startup phase and DOE funding is focused on determining the requirements and the "analytical gaps" of the subprogram and resolving these issues. However, as suggested, DOE will continue to critically assess projects for redundancy and opportunities for cost reduction.

Systems Analysis Funding:

The funding portfolio for Systems Analysis addresses primarily the analysis model support and development to reach the 2015 Commercialization Decision. The requested FY2006 funding profile, subject to Congressional appropriation, addresses the National Academies' Report recommendations and provides greater emphasis on transition.

Majority of Reviewer Comments and Recommendations:

In general, the maximum, minimum and average scores of the reviewers for the Systems Analysis projects were 3.7, 2.7, and 3.2, respectively. The Systems Analysis project portfolio includes a mix to address the "analysis and modeling gaps" of the subprogram and the transition requirements. The major recommendations for the Systems Analysis are summarized below. DOE will act on reviewer recommendations as appropriate for the overall Systems Analysis effort.

- H2A Modeling Tool: Focus on the model functionality and its role in the overall planned model architecture.

- Transition Analysis and Models: Develop an approach to utilize industry collaboration to validate the models and analysis. Automation and optimization in the model structure will be essential to understanding the model benefits. Emphasis on the ability to link the models, particularly with the H2A models and the future Macro System Model, is required.

- Resource Analysis: Focus on combining the resource analysis with other analysis projects. Ensure a common set of assumptions are used for the analysis basis.

- Hydrogen Supply and Infrastructure Analysis Model (WinDS/HyDS): Focus on linkage and integration with other models but minimizes redundancy. Introduce more hydrogen production technologies beyond wind in the model structure. Incorporate industry, academia and other national laboratory personnel in a peer review of the model.

Project # AN-01: Systems Analysis
Joseck, Fred; U.S. Department of Energy

Brief Summary of Sub-Program

The purpose of this Systems Analysis Overview and introduction is to describe analysis goals/objectives, budgets, barriers/targets, approach, technical accomplishments, interactions and collaborations, solicitations and awards, and future directions. As such, it sets the stage and puts into context the Systems Analysis projects which will be presented during the Annual Merit Review.

Degree to which the Sub-Program area was adequately covered and/or summarized

- A comprehensive, well-developed and understandable presentation was delivered by the sub-program manager.
- Issues, accomplishments, plans, future milestones were all discussed and clear.
- For next year: Show all the sub-program's analytical parts, how they do/do not fit together, and the plan for fitting them together better in the future.
- This was a coherent and complete summary.
- It was a thorough and detailed presentation that made clear the issues and concerns and provided methodologies for addressing them.
- The program was well described but would benefit from an overview of the respective roles of various models and any overlaps.

Were important problem/issue areas and challenges identified/discussed, including plans for addressing these items in the future?

- The challenges and issues associated with achieving a complete, coordinated analytical effort were identified objectively and accurately. Historically separate analytical activities are being brought together, integrated and used effectively.
- Yes, although more detail would have been useful (but would have required more time).
- Presentation was clear in identifying issues and ways to address, but achieving this is acknowledged to be a challenge given that there is a lot of 'herding of cats' involved.
- The forward plan is consistent with addressing barriers. Barriers identified appear to be comprehensive.

Does the Sub-Program area appear to be focused, managed well, and effective in addressing the Hydrogen Program R&D needs?

- Discussion of systems analysis planning suggests that this complex sub-program is receiving appropriate management attention.
- The planning, accomplishments and budget indicate that the sub-program is a priority for management.
- A long needed plan has finally been developed, although the details of the plan were not discussed.
- The program appears focused on addressing identified needs. Some concern exists around trying to ensure coordination and cooperation with other parts of the program (and other DOE offices, e.g., Fossil Energy) and seeing the 'big picture'.
- As this sub-program is now covered by a plan, it can be expected that it will now be managed with greater focus and cohesion.

Other comments:

- $7.1 million annual budget (FY06) is a pretty steep cost.
- Need to assess, identify opportunities for reducing costs without sacrificing results.
- Not clear if completely "linked" Macro Model is necessary and funding may not be adequate.
- How will the program collate the various analysis tools and models such that there can be an 'official' view on a particular topic, e.g., transition, costs, policy requirements, etc.? Potential exists for multiple views on a particular topic creating division and confusion -- perhaps there is scope for an analysis project that collects all analysis on a particular topic and creates one official view?
- The overall architecture of the models should be designed so that greater direction is available for individual model development. This architecture should flow from the Macro Model. The Macro Model will need simulation, optimization and decision functions.

Project # AN-02: Moving Toward Consistent Analysis in the HFC&IT Program: H2A
Mann, Maggie; National Renewable Energy Laboratory

Brief Summary of Project

The H2A project team's goal is to bring consistency and transparency to hydrogen analysis. Phase I goals include production and delivery analysis, consistent cost methodology, critical cost analyses, and tool development for providing R&D direction.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.7** for its relevance to DOE objectives.

- It would be better to write on the objectives of the program: "Tool for helping decision makers on R&D direction".

Overall Project Score: 3.7 (6 Reviews Received)

- This work is important for DOE and other decision-makers throughout the hydrogen community.
- This does not contribute directly to achieving hydrogen economy, but it should make getting there more efficient and cost-effective.
- The project's objectives are very clear and indeed crucial to an orderly and consistent analysis for the H_2 program.
- The goal of the project is to consolidate analytical capability and make data consistent, which would be essential in the realization of the President's Hydrogen Fuel Initiative.
- There was a frequent reference to H2A across the different elements of the hydrogen program, which provides a unifying role for the R&D effort.
- This is an important step towards standardizing hydrogen delivery cost analysis.
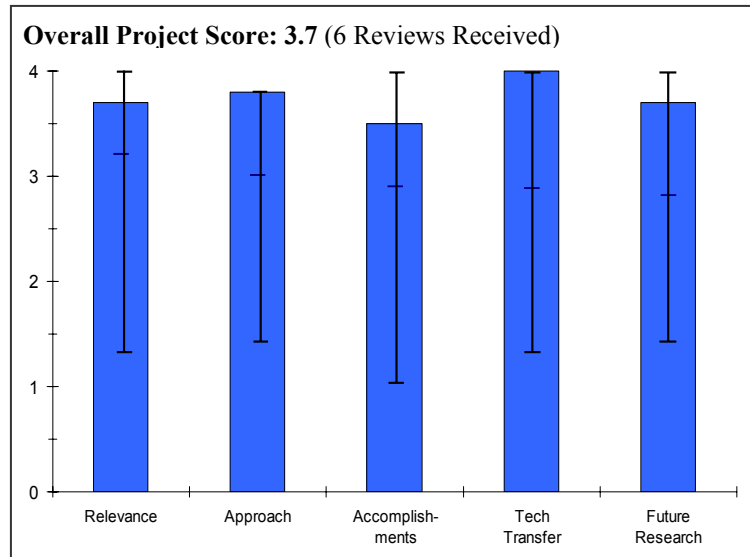
Question 2: Approach to performing the research and development

This project was rated **3.8** on its approach.

- There should be a higher focus to quantify uncertainties to demonstrate how much these uncertainties are involved in the results and the limits/tendencies of the results. To establish the curves, it is necessary to have a good effort and interaction among experts in order to contribute even more for the entire study. This is different from sensitivity analysis, especially in an 'if-then' type of analysis.
- The basic approach to production modeling is cash flow analysis tool.
- Accurate, useful results depend on quality of inputs, including those from parties with vested interests and possibly conflicting agendas. (See criterion 4).
- The approach is very thorough and effective, however, it may be a little slower than originally envisaged.
- The model presented is consistent and complete, yet allows for great deal of flexibility.
- The approach has already been very successful because it includes a comprehensive involvement of stakeholders.
- This project directly addresses targeted barriers and incorporates many other research organizations directly into the team.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.5** based on accomplishments.

- It is doing very well.
- Version 1 of H2A is an excellent start in achieving analysis sub-program objectives.
- Version 2 will be another critical step.
- The rate of progress may have been a little slower than anticipated, however, it is better for the result to be a complete job rather than a quick job.
- This project is steadily making progress to add more analytical capabilities to the tool.
- Technical accomplishment is commensurate with this stage of the project.
- There is good progress within the limitations of the available budget resources.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **4.0** for technology transfer and collaboration.

- Very good network, however, consider to include the car industry and the fuel companies.
- There are a number of partners on the team.
- There are also lots of industrial collaborators.
- This project effective exchanged information with and used results achieved by others doing similar modeling.
- The involvement of the DOE and external modeling community and industry feedback/peer review is exemplary.
- The involvement of H2A provides extensive collaboration.
- Collaboration is a great strength of this project.
- This presenter is also integrated with other researchers on a team.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.7** for proposed future work.

- This project has an impressive plan.
- Future work is needed to improve the identified H2A model capability.
- Complete the linkage to delivery module.
- The responsiveness to enhancements suggested from beta testing is good and benefits the program.
- The planned extension to other parts of the H_2 program is essential.
- The planned work is appropriate. An important issue, however, will be how this project interfaces with the Macro model.
- This team appears to recognize that much of the value of its work lies in using the model to put future analyses on a common basis, e.g., application to technology validation projects.

Strengths and weaknesses

Strengths
- HFC&IT management commitment to a strong, well-integrated analysis and modeling capability.
- This H2A team has the ability to work constructively with other organizations, particularly industry.
- Since this model is Excel based, its potential users can easily understand it.
- There is a strong involvement of multiple stakeholders, including industry.
- There are consistent data sets due to the development of the data book.
- Their intent is to enforce consistent data and assumptions throughout the H_2 Program.
- The clear and extensive collaboration on this project appears to be drawing together many of the R&D projects.
- This model serves as the repository for agreed data.
- Large numbers of collaborators are both incorporated into the team and provide input from the periphery.
- There is a good focus on targeted barriers.

<u>Weaknesses</u>
- This project does not start with a "clean sheet," so it must adjust models. Other "legacy" activities need to incorporate them and use them efficiently as part of this initiative.
- The core calculation as represented in the presentation appears to have some issues. The income calculation appears to be misrepresented: the income would normally be ($/kg x Kg/year) not ($/kg / kg/year). Cash flow would not normally include depreciation - perhaps this represents debt principal payments.
- Representation of capital cost changes over time and appears more arbitrary than in HyTrans, in which the economies of scale and learning curves are adopted.
- This is a big job with relatively limited resources.

Specific recommendations and additions or deletions to the work scope

- The EIA data do not consider the success of the hydrogen economy; it should be analyzed.
- The model only addresses a single production source - could multiple sources be incorporated?
- As with the other models, the interface between models and the planned Macro model are not yet clear. All modeling projects would benefit from an overall planned model architecture that outlines planned functionality of each model and its intended role.
- The H2A model appears to have the greatest potential to provide a common data set for hydrogen system components in a way that can then be used as a subroutine for a wider simulation and/or optimization model.

Project # AN-03: Hydrogen Transition Modeling and Analysis: HYTRANS v. 1.0
Greene, David; Oak Ridge National Laboratory

Brief Summary of Project

Oak Ridge National Laboratory has created a preliminary working version of an integrated model of the market's transition to hydrogen as a transportation fuel using non-linear optimization methods. The model includes representation of hydrogen production and delivery; vehicle production, including technological progress, scale economies and learning-by-doing; and demand for vehicles and fuels, including the effects of fuel availability and diversity of vehicle choice. Future development will focus on continuous improvement of model components, producing a regional model, generating plausible scenarios of the transition to hydrogen based on DOE MYPP goals and other technology forecasts, and publishing model documentation and scenario analyses.

Overall Project Score: 3.3 (7 Reviews Received)
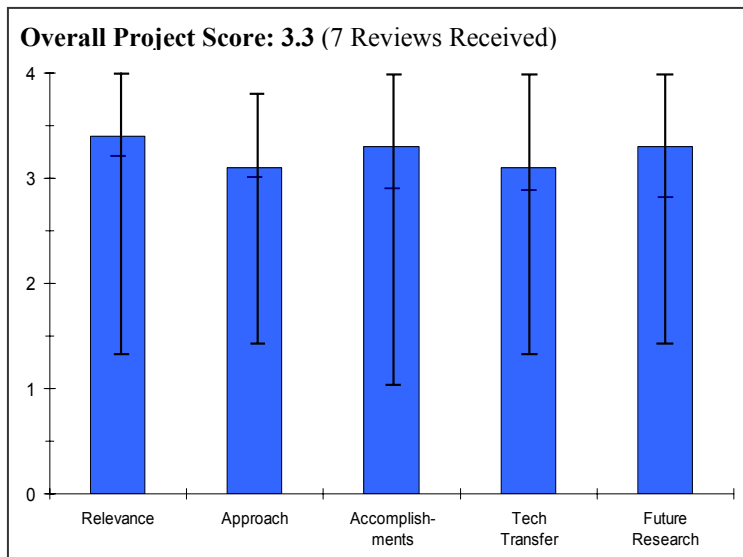
Question 1: Relevance to overall DOE objectives

This project earned a score of **3.4** for its relevance to DOE objectives.

- The project will be relevant especially when linked to a Macro model.
- The understanding the FCV buildup is an important input to many other analysis topics.
- The transition analysis is very important.
- This project scored a 3 because its transition analysis is only part of the overall System Analysis set of objectives.
- Based on the presentation, the analysis seems rather incomplete with respect to competition of various fuel options (hydrogen fuel cell, diesel, gasoline, and hybrid vehicles).
- The project addresses barriers C, D and E.
- The alignment of input assumptions with other modeling projects would assist with Barrier B.
- This is a useful analytical tool for addressing the transition.

Question 2: Approach to performing the research and development

This project was rated **3.1** on its approach.

- Improved work to establish the best representative scenarios should be completed
- FCV may bring other attributes to the market (120 V capabilities, noiseless, new designs related to wireless possibilities, etc.) that is not considered on existing correlations.
- Geographical specificities should be represented.
- Uncertainties in quantification should be considered.
- This approach may be too detailed for the level of accuracy expected from a consumer choice model.
- Is there a way to validate the results?
- Market equilibrium solutions are the ideal approach.
- Nonlinear optimization is very useful.
- This project has added H2A cost computation for consistency.
- The approach is very thorough and complex.
- Glad to see there were no equations in the presentation!

- Based on the presentation, the model developed seems to be rather complex. The presentation of the model should be improved to convey the message of the model. It was difficult to determine what the approach was, and particularly, what the assumptions were.
- The scenario analysis approach in the model along with an optimization process appears to be a very suitable framework for studying the transition to hydrogen use.
- Further description of the optimization process and the objective function would assist evaluation of the approach.
- Addresses targeted barrier directly. Good integration with other research, particularly H2A. Broad scope (vehicle technology choices, demand projections, infrastructure choices, infrastructure implementation - with optimization laid on top of all that), may have been a bit too ambitious.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- The non-linear optimization model as reported should become a target in the model development too.
- It is not clear if consumer preference is accurately represented.
- I am looking forward to more substantial results and conclusions in the next review period.
- Incremental work this year is on track - have working model to show feasibility.
- Delivery system model is preliminary - awaiting H2A delivery results.
- Preliminary results are interesting.
- This progress has been impressive and wealth of included detail.
- The extension of model capabilities is also impressive to include scale effects, learning effects, etc.
- The scenario results are presented in a concise and useful manner.
- It was interesting to note that the introduction of a hydrogen vehicle subsidy prevented the adoption of hybrids, eliminating early gains but creating long term gains. This would appear to force all efforts towards hydrogen, reducing diversity of solutions.
- This project has good progress vs. scope.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.1** for technology transfer and collaboration.

- The interaction and integration with H2A models should be intensified.
- Other experts should be considered to review and help the development.
- This could benefit from a more detailed review and feedback from other analysts/industry.
- Good collaborations with H2A group & UC Davis.
- This project relies on other models where appropriate.
- Consumer choice model needs to be fed to "macro-system model".
- There is a good inclusion of other critical models such as H2A, GREET, etc.
- It would be appropriate to see wider peer review.
- The extent of collaboration was not clear from the presentation.
- The modeling framework used in this project may well be useful in other projects.
- Good coordination.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.3** for proposed future work.

- It is well defined.
- The linkages to other models/analyses will provide significant benefits.
- Consideration of appropriate scenarios will be very important.
- Hooking this modeling effort to NEMS does not make sense to me.
- Future work should focus on relating this effort to the "macro-system" model.

- The work needs to interface into the Macro System model and work toward that.
- It is not clear what contingencies and optional analysis paths are being considered.
- Additional H_2 production paths should be incorporated at an early stage.
- Both the sensitivity analysis and linkage to the Macro Model will be useful steps.
- Plan appears sound.

Strengths and weaknesses

Strengths
- The market equilibrium concept using nonlinear optimization is an excellent approach.
- This approach will be a necessary component of the macro-system model in future work.
- The authors' experience in modeling consumer vehicle choice is valuable to macro-system model.
- The analytical approach used is quite powerful and has potential for other projects.
- The use of economies of scale, learning curves and technology change price reductions appear to be strength of the model.
- This project addresses a broad spectrum of topics over a wide transition window.

Weaknesses
- The first version of the model and its preliminary results are really for demonstration purposes only; nevertheless, the demonstration of the market analysis is a very important contribution to the overall H_2 system modeling program.
- The complexity of the modeling and associated mathematics/computing unfortunately detracts from ease of understanding of the detail and hence could reduce confidence in results.
- It is unclear how much model testing has taken place to validate results against, e.g., H2A.
- The presented results don't seem to reflect even the current mix of fuel types, especially hybrid gasoline and diesel.
- The use of common assumptions with other models would increase the comparability of the results of this project with other projects.
- The uncertainty as to whether the optimization process is finding the best solution is a concern.
- This project may be too ambitious, which could lead to modeling compromises that limit usefulness of results. The tendency of the model to make "either/or" technology choices (reality usually involves more of a technology mix) may be indicative of the effect of such compromises.

Specific recommendations and additions or deletions to the work scope

- Reaching the limits of the non linear optimization software leads to a concern over modeling for modeling's sake. To what extent are reasonable compromises possible in some areas to facilitate analysis, especially if it is desirable to incorporate geographical, i.e., greater detail?
- The use of assumptions that are common across analysis projects is important.
- An optimization process like this has potential in the macro model.
- The transition to hydrogen could be modeled using a decision based model where uncertainties in future market and technology outcomes can be considered in the model. This may assist in determining which R&D investments should be adopted given an assessment of probability of outcomes.
- The inclusion of hydrogen hybrid ICEs would be useful so that it can be assessed as a potential transition technology.

Project # AN-04: WinDS-H2 Model and Analysis
Short, Walter; National Renewable Energy Laboratory

Brief Summary of Project

By the end of FY 2004, the National Renewable Energy Laboratory completed the basic modeling structure of HyDS (renamed from WinDS-H2), implemented the most current data from the H2A effort, and used the HyDS model to analyze a base case. These results focused on the capability of wind to produce hydrogen for use as a transportation fuel and as a means of storage at the wind site. In FY 2005, NREL will refocus the model to encompass a larger range of production technologies and H$_2$ fuel distribution possibilities, as well as use the model to evaluate several scenarios.

Overall Project Score: 2.9 (7 Reviews Received)
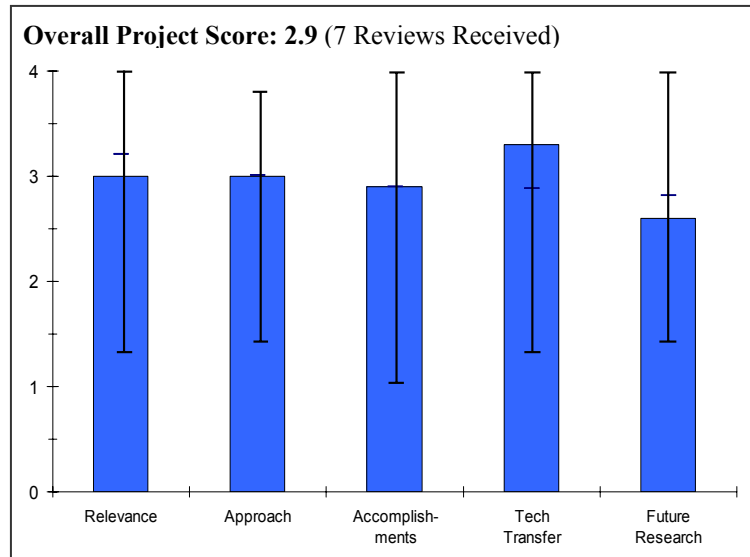
Question 1: Relevance to overall DOE objectives

This project earned a score of **3.0** for its relevance to DOE objectives.

- This project should be integrated with a macro model.
- Part of its effort has been addressed in other projects.
- It is not clear if distributed electrolysis hydrogen production from central wind (i.e. renewable electricity distribution) will contribute to HFCIT goals. Focus should be on vehicle application (i.e. pipeline hydrogen delivery).
- There is strong program relevance of wind-to-H$_2$.
- I also see this as a small but interesting step in the direction toward the "macro-system" model.
- The fit and relevance of the Win-DS model to the H$_2$ program is not clear from the presentation; this is a relatively small subset activity that may not apply for a long time.
- The scope is narrowly focused on wind, whereas the President's Hydrogen Fuel Initiative supports a diversity of fuels and feedstocks. The project would be more relevant if additional fuels and feedstocks were at least used for comparison to the wind scenario(s).
- This appears to be a key element of modeling, bringing together electrical and hydrogen systems.
- The original intent of project appears to more oriented towards wind energy and finding a role for it in hydrogen than in promoting the hydrogen objectives.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Integration with a macro model is necessary.
- Uncertainties should be quantified.
- Wind should be competing with other renewable resources.
- It is not clear if low-volume SMR capital costs are used. H2A cases for SMR are for high production volume only.
- The regional model is good for evaluation wind production potential.
- It appears the H$_2$ production & transport maybe redundant with other efforts in the program (such as H2A-delivery).
- The linear minimization technique is not as powerful as the nonlinear method used in HyTrans.
- The use of H2A data gathering is commended to avoid duplication and ensure commonality of data.

- The future energy mix does not seem realistic or consistent with DOE's long-term objectives. The assumption is that coal, wind and (second half of the legend is unreadable) will grow, and other sources, such as nuclear, will steadily decline. This seems to be in conflict with DOE priorities (though perhaps not EIA projections).
- The treatment of the electrical system is quite sophisticated.
- This approach does not address some of the identified barriers: it is not really a macro system model nor does it contribute to eliminating "siloing" (it does take advantage of other programs that do). It does look at transition, but more in terms of how transition might drive this technology, rather than how the technology might drive the transition.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.9** based on accomplishments.

- The results do not necessarily add significantly to our understanding of the transition to hydrogen vehicles or the potential for using wind resources for this purpose.
- It started from existing WinDS model.
- Renaming the H_2 version of model is slightly misleading, because the focus & strength of the work is the renewable (wind) component.
- The comparison of distributed electrolysis, wind-electrolysis, & distributed SMR is interesting.
- It is hard to rate the new project development of existing project.
- Good progress on wind and SMR, addition of other technologies will be important.
- This group has accomplished what it set out to do.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.3** for technology transfer and collaboration.

- This is a very good team.
- They could use more non-wind industry feedback and collaboration with other analysis projects.
- Collaboration with H2A effort - using their cost database.
- The project uses multiple collaborations (Wind group, H2A) but could usefully be peer reviewed for overall fit in the H_2 program and alignment of goals, i.e., where does it fit in the big picture ?
- Extensive collaboration, including with H2A and wind community.
- Good to see collaboration with H2A etc.
- Appear to have coordinated with H2A.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.6** for proposed future work.

- It is trying to replicate some of the work planned at the H2A.
- It should to integrate with a H2A macro model (HYTRANS at least).
- Proposed future work should have been part of the original scope.
- Any of the plans the author mentioned involve additions to the model that overlap with what will be needed in the "macro-system" model.
- Since this project is not designed to become the "macro-system" model, the future plans should be aimed at providing a wind sub-model for the larger macro-system effort.
- The project did not explain the future direction in a clearly understandable way with appropriate rationale.
- The projects proposed future research still does not include nuclear - though the larger DOE hydrogen program and other DOE initiatives do.
- There is the potential for duplication if this model remains isolated from other models.
- Project has served its purpose. Although it is now attempting to adapt model to scenarios outside of its scope, other projects may cover the same territory.

Strengths and weaknesses

Strengths
- The regional wind model is necessary for analyzing the renewable production of H_2.
- This model should be included in the macro-system modeling effort.
- Strong detailed assessment of the wind aspects.
- There is a representation of the electrical system in detail and the approach to transmission augmentation.
- This project provides a realistic analysis of the potential role of wind in the hydrogen program.

Weaknesses
- This model continues to build other H_2 production & transportation modeling which seems redundant with what the macro-system model will eventually need to do.
- The presentation was hurried and confusing without clear rationale for why the work is being done and how the results fit into an overall view of a future H_2 economy. It seemed that there were good reasons behind the results being presented but this was not coming through clearly.
- Use of a fixed cost ($2/kg) for H_2 seems an oversimplification.
- Focus on wind scenarios (though the basis is reforming of natural gas) sounds more like a biased sales pitch for wind than an independent, and hence legitimate, analysis.
- The examination of wind in detail without a defined interface with other models is limiting.
- Some of the model assumptions (H_2 produced in off peak) appear to be untested - why not test sensitivity to these assumptions. There may be a trade off between electricity price and equipment utilization. Perhaps shoulder price H_2 production would be more optimal.
- There is the potential for duplication if this model remains isolated from other models.
- Whilst there is a good representation of the electricity system, key barriers such as wheeling charges may not have been addressed.
- This project is more focused as a wind project than a hydrogen project.
- This project is not well-aimed at resolving identified barriers.

Specific recommendations and additions or deletions to the work scope

- This appears to be a relatively narrow topic, especially for the near term.
- The reduction in common power electronics cost for wind turbine co-located with the electrolyzer is not convincing.
- Inclusion of GHG effects would be valuable - electrolyzers using grid electricity.
- This project needs collaboration with other modeling activities to help show its relevance.
- Do not ignore nuclear energy specifically, without a stated justification or reason.
- This work should be integrated into a macro model so that the detailed wind analysis can be considered in comparison to other sources.
- Not clear whether transmission losses are considered.
- Proposed change in scope to model other technologies could salvage this as a hydrogen project, but there should be a careful look at the relevance of this project vs. other efforts.

Project # AN-05: Technical and Economic Studies of Regional Transition Strategies toward Widespread Use of Hydrogen Energy
Ogden, Joan; UC Davis

Brief Summary of Project

This University of California, Davis project will develop new simulation tools to evaluate alternative pathways toward widespread use of hydrogen under various demand scenarios and regional conditions. Tasks are to understand which factors are most important in finding viable transition strategies, to develop "rules of thumb" for future regional hydrogen infrastructure development, to conduct regional case studies of H_2 infrastructure transitions, and to work with the H2A core group to develop models of hydrogen delivery systems.

Overall Project Score: 3.3 (6 Reviews Received)

Question 1: Relevance to overall DOE objectives
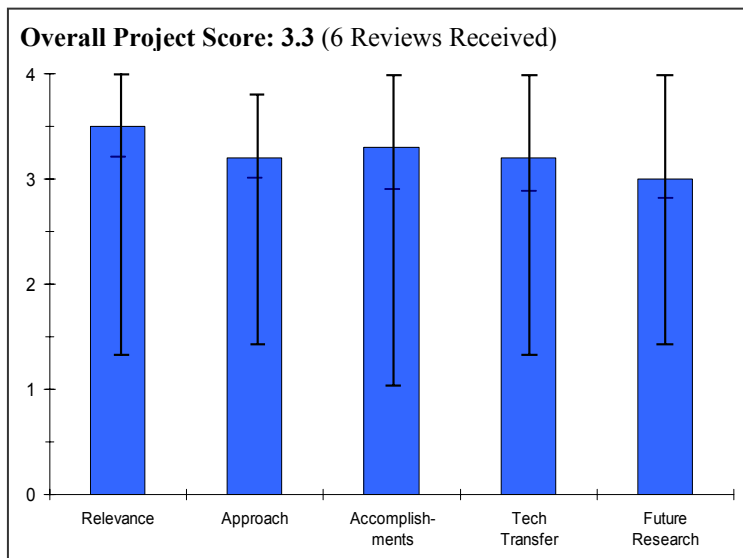
This project earned a score of **3.5** for its relevance to DOE objectives.

- It has been helping several other studies.
- It should help the integration of several H2A models into a single macro model (regionally based).
- Transportation issues are critical to understanding which hydrogen technologies should receive the most attention.
- The objectives were clear and focused on meeting transition analysis needs.
- Understanding of the phenomena associated with regional transitions to the hydrogen economy is essential in light of the fact that regional demand and availability of resources will define regional economics and therefore inform feedstock and technology choices.
- This approach can prepare an infrastructure plan that could be generally specified by a higher level optimization or simulation model.
- This is useful work for understanding the transition.

Question 2: Approach to performing the research and development

This project was rated **3.2** on its approach.

- Uncertainty analysis should be performed. It is different than sensitivity analysis because it quantifies the inherent uncertainties, the limits for them and the tendencies (possibility for a certain scenario to occur).
- Existing fuel station sites should be considered primarily.
- Approach seems to have evolved over time rather than following a set plan, but probably reasonable given DOEs evolving needs.
- The approach embodies a pragmatic 'rule of thumb' methodology that is easily understood.
- Tool developed is exclusively applicable regionally; however, it is generic enough to be applied to a variety or regions with specific case studies.
- The core approach is very useful for the examination of hydrogen infrastructure development.
- Inclusion of other sources will enhance its applicability.
- This approach addresses the targeted barriers.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Progress is not very significant this year. However, the project progress was impacted by the by the project funding.
- Progress is pragmatic, yet relatively simple; the approach is easy to validate and test and leads to credible and understandable results that are easy and relatively quick to prepare.
- The case study provided was developed to a point of completeness and a useful result.
- Good progress to date; the group has developed some useful tools.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.2** for technology transfer and collaboration.

- This group appears to have worked closely with the H2A team; however, more industry input is needed.
- Collaboration with other programs allows good interchange of data and review of methodology, e.g., Pathways, H2A.
- Extensive collaboration with H2A, Industry, other Universities, and NREL.
- Good collaboration is evident in this group.
- Good coordination with other efforts.

Question 5: Approach to and relevance of proposed future research

This project was rated **3.0** for proposed future work.

- The group needs to focus efforts and analysis on establishing the necessary assumptions.
- No need to estimate market penetration for consumer choice - ORNL is already doing this. Other proposed work that looks reasonable.
- Encourage the use of rules of thumb.
- Interaction with H2A and development of reasonable scenarios for transition are also very valuable.
- Continuation of pragmatic approach lends credibility to output.
- Work proposed would seem to lead to a general understanding of how various factors would affect a transition to a hydrogen economy.
- This project would benefit from the addition of an automation process to enable multi region infrastructure development.
- This group's plans are appropriate for remaining scope.

Strengths and weaknesses

Strengths
- Most of the other analysis projects are using the support of this project.
- This project uses a pragmatic approach, utilizing case studies, to ease understanding.
- Inclusion of GHG consideration and effects good.
- The project was presented very clearly and methodically.
- Strong GIS base, approach to routing of infrastructure.
- Very detailed.
- Useful tools.
- This project provides valuable learning's in terms of how to analyze specific transition cases.

Weaknesses
- The group should perform uncertainty analysis.
- Lack of automation.
- Lack of optimization.
- It is a static representation.
- There is a limited scope.

Specific recommendations and additions or deletions to the work scope

- Keep supporting it.
- Include as an algorithm in the macro model.
- If automated, has potential to be used to detail scenarios that are either directly developed or result from an optimization process.
- The ideal networks could be ground truthed against actual city layouts and then calibrated to key city characteristics.

Project # AN-06: Fuel Choice for FCVs: Hydrogen Infrastructure Costs
Lasher, Stephen; TIAX LLC

Brief Summary of Project

TIAX has previously evaluated the long-term benefits and costs for a wide range of vehicle/fuel pathway combinations. Based on the promising long-term benefits but uncertain near-term costs for compressed hydrogen as a fuel for fuel cell vehicles, TIAX is currently evaluating the transitional costs of various hydrogen fuel infrastructure pathways using a net-present-value-type analysis for the entire United States.

Question 1: Relevance to overall DOE objectives

This project earned a score of **3.2** for its relevance to DOE objectives.

Overall Project Score: 3.2 (6 Reviews Received)
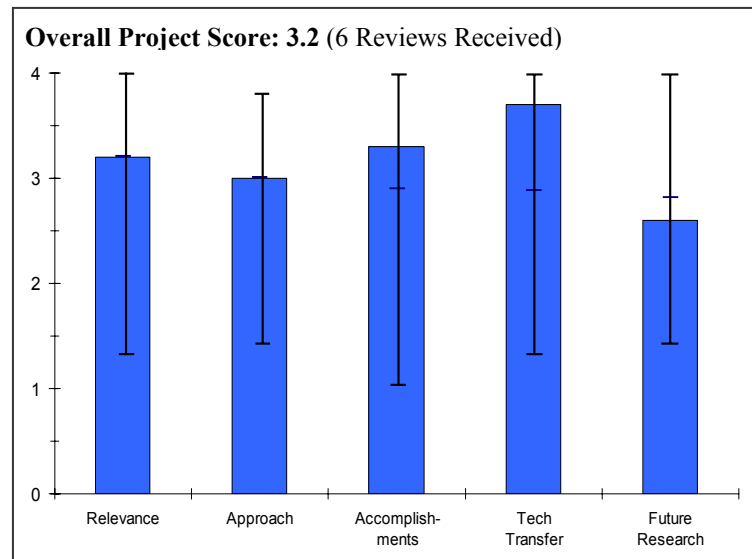
- This project is duplicating efforts with several H2A project.
- It should contribute to the development of a macro model integrating several analysis sub-projects.
- The group should focus is on capital costs and risks for infrastructure investors. Investor views of financial attractiveness of hydrogen investments will be a key factor in timing, pace of moving to a hydrogen economy.
- This project can provide valuable inputs for work that more directly impacts achievement of hydrogen program objectives.
- The objectives were well laid out and show clear linkage to DOE goals.
- The project is highly relevant because the reduction of capital cost is essential to the successful transition to the hydrogen economy.
- The analysis of the existing excess hydrogen capacity has particular potential to assist transition analysis.
- A very thorough and detailed analysis of transition scenarios.

Question 2: Approach to performing the research and development

This project was rated **3.0** on its approach.

- Uncertainties should be addressed and quantified.
- A better data treatment and scenario composition methodology should be developed.
- Work on this project preceded initiation of H2A activities.
- Approach utilizes separate TIAX assumptions to some extent.
- Approach being modified to use inputs, assumptions from other models.
- Use/involvement with H2A has been valuable to consistency between the program results and other DOE work.
- Steam reforming (both central and distributed) were addressed in the project, however electrolysis was not. The reason was not discussed.
- The deterministic approach to scenarios is informative but would be enhanced if the scenarios were as a result of an optimization process.
- Project addressing targeted barriers, and is well integrated.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **3.3** based on accomplishments.

- Work on this project is providing results and insights that are useful for government and private sector decision-makers.
- Some demand modeling is being done- a plus.
- Overall, good value for relatively small resources being spent.
- Results invite credibility due to clarity and presentation style.
- Derivation of older model a cost effective way to proceed with enhanced analysis.
- The case study on use of existing potential H_2 production was a good test.
- The meaningfulness of the scenarios is unclear but the excess hydrogen information is very interesting.
- Have completed a very thorough analysis of the scenarios addressed to date.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.7** for technology transfer and collaboration.

- Some coordination of work with H2A.
- Project team collaborates with a number of organizations.
- Collaboration seems to have been good with diverse participants.
- The project assumptions seem excessively conservative - to the point that if market penetration were that low the hydrogen economy would probably not be feasible.
- Collaboration and response to previous year review is evident.
- Very good integration.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.6** for proposed future work.

- Wind and electrolyzer model have been done on other projects.
- Proposal submitted to DOE on renewable pathways to hydrogen. No details provided.
- Need to clarify how proposed future work adds value, complements other analyses at national labs, universities.
- Project is nearing end so not much future work was discussed. Extension to renewable pathways makes sense.
- This is the last year of the project.
- Integration with other models is probably the key next issue.
- This project will significantly enhance the scope of the work.

Strengths and weaknesses

Strengths
- The assessment of excess existing hydrogen capacity.
- The use of an NPV approach is a useful tool for examining scenarios.
- Realistic scenarios.
- Very thorough.
- Credible results.
- Very good solicitation and use of outside sources.

Weaknesses
- Unable to determine how effectively this work on hydrogen transition modeling is being linked/ integrated with other program-sponsored transition modeling.
- The presentation was somewhat hurried and did not allow sufficient time to understand the assumptions made to generate the various scenario results - it sounded as though many were simply what-if type guesses.
- Given that making ammonia and methanol is not economic with high US gas prices it is suspect to assume that low cost H_2 can be obtained from these plants unless you assume that costs are all sunk already?
- The manner in which the scenarios have been established.

Specific recommendations and additions or deletions to the work scope

- When additional assumptions have been required in analysis projects, these should be documented and captured in the data book.
- Combining this work with other analysis results to generate a consensus view would be valuable.
- Follow on work (if any) should assume a shorter transition. It seems highly unlikely that there would ever be a hydrogen economy if there was only 30% market penetration in 2060.
- The inclusion of the excess existing hydrogen capacity in other models is necessary.
- The analysis of scenarios that emerge from other optimization models would validate both models.

Project # ANP-01: Hydrogen Production in a GHG-Constrained Situation: Major Results & Conclusions
Dougherty, Bill; Tellus Institute

Brief Summary of Project

Tellus Institute is examining in a detailed quantitative manner, plausible scenarios for a transition to a hydrogen economy. They will explicitly illustrate the staging and sequencing of major phases of the transition scenarios and their implications, quantify the greenhouse gas reduction benefits of each of the transition scenarios, explore the spatial characteristics of the transition scenarios based on GIS analyses for four greater metropolitan areas in the United States (Boston, Denver, Houston, and Seattle), and account for relevant techno-economic and policy factors.

Overall Project Score: 2.7 (7 Reviews Received)

Question 1: Relevance to overall DOE objectives
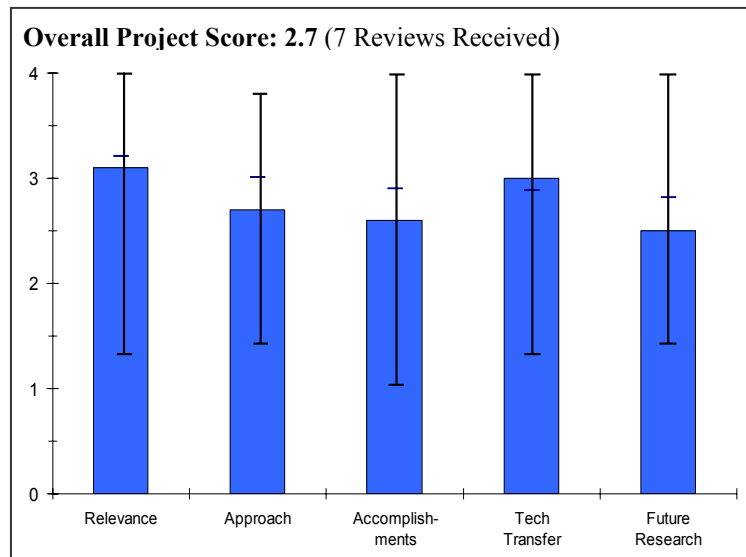
This project earned a score of **3.1** for its relevance to DOE objectives.

- Replicate efforts with H2A project.
- Stated objectives are reasonable and in line with DOE goals.
- The analysis of transition is important to program planning.
- This project was started prior to planning for the "macro-system" model - some aspects of the effort may be applicable to the larger effort.
- The project has clear objectives and was well presented.
- Limited focus - suggest including nuclear (and other non-GHG producing electricity) and not limit application to hydrogen fuel cell vehicles.
- The objective of this project is directly relevant to the hydrogen objectives and program.
- Useful analysis of a transition scenario.

Question 2: Approach to performing the research and development

This project was rated **2.7** on its approach.

- "If-then" scenario type is a poor approach.
- The location of existing fuel station should be considered.
- Description of the approach was not clear.
- Created a new model that reflects the NEMS model - I see limited value in this approach.
- Extending projections to 2050 based on other published projections is not very predictive.
- Assumption of a dual-fuel vehicle, while considered by an OEM (BMW) is not a good idea - experience with other AFV programs has shown that consumers don't use the alternate fuel, so these dual use vehicles don't help develop the fueling infrastructure.
- The basing of the demand on Annual Energy Outlook 2003 made a lot of sense and is very defensible.
- Broader focus would make conclusions on advantages of hydrogen with respect to GHG emissions more meaningful. Specifically -- change of mix of grid electricity and increase hydrogen applications.
- An interesting representation of geographic distribution of demand over time.
- Assessment of CO_2 emissions is helpful characterization of the results.
- The work itself was consistent with the objectives, but there appeared to be a possible disconnect when translating the work into conclusions.

Question 3: Technical accomplishments and progress toward project and DOE goals

This project was rated **2.6** based on accomplishments.

- Old conclusions using old approaches.
- Conclusions are very reasonable, but it is not clear how they were determined.
- The project shows progress with plenty of results.
- Projections are subject to the assumptions regarding vehicle penetration.
- There is a lack of a market feedback mechanism limits the strength of the conclusions.
- This presentation had inadequately documented graphs.
- While not unexpected the results confirm other work. Conclusions were clear and logically presented.
- It is not clear how the conclusions have been drawn from results from the project to date.
- Good work, strange-appearing conclusions.

Question 4: Technology transfer/collaborations with industry, universities and other laboratories

This project was rated **3.0** for technology transfer and collaboration.

- Car industry and fuel companies should be involved.
- This project would benefit from a deep dive into the model assumptions.
- Writing their tool in VBA would allow for transfer to other users, including possibly the macro-system modeling effort in the future.
- A number of collaborators were listed but it would have been good to see more industry participation.
- Not assessed.
- Good interaction.

Question 5: Approach to and relevance of proposed future research

This project was rated **2.5** for proposed future work.

- The benefit of doing a localized study is to bring the specificities of the region into consideration.
- It is not offering too much contribution on the methodology or on the political discussion.
- It is not clear that future work is necessary.
- Many of the next steps seem redundant with other modeling efforts in the analysis program.
- While the authors are thinking about the macro-system modeling needs, the future planning does not seem to suggest how they would contribute to that developing effort.
- The project is nearing completion; discussions on any future work have not yet taken place.
- Proposed future research includes additional use of non-GHG emitting technologies, however work should be broaden further to cover more "realistic" future energy mixes and more innovative/extensive hydrogen applications.
- Not assessed.
- Project appears to be finished.

Strengths and weaknesses

Strengths
- Thorough analysis, well presented and understandable results.
- GIS analysis system.
- Good, detailed work.
- Useful learning's on how to do analysis that can be applied to future work.

Weaknesses
- It was not clear that H2A assumptions are being used though this project may pre-date H2A.
- Presentation used excessive (and mostly undefined) acronyms and abbreviations.
- Conclusions are not demonstrated in presented results.
- There is a lack of optimization process to define the scenarios used.
- Conclusions based on observations that are inconsistent with other work (e.g., "Hydrogen FCVs are unlikely to be cost competitive with gasoline ICEs").

Specific recommendations and additions or deletions to the work scope

- The project was concise and easy to understand unlike several others which often show excessive detail and confuse the message, i.e., modeling for modelings sake not for the analysis of the results.
- Adoption of scenarios produced by optimization models would assist in validating modeling.
- Modeling of the same region as is being studied in other models would assist validation.